

BULLETIN 228

AUGUST, 1914

NORTH CAROLINA  
AGRICULTURAL EXPERIMENT STATION

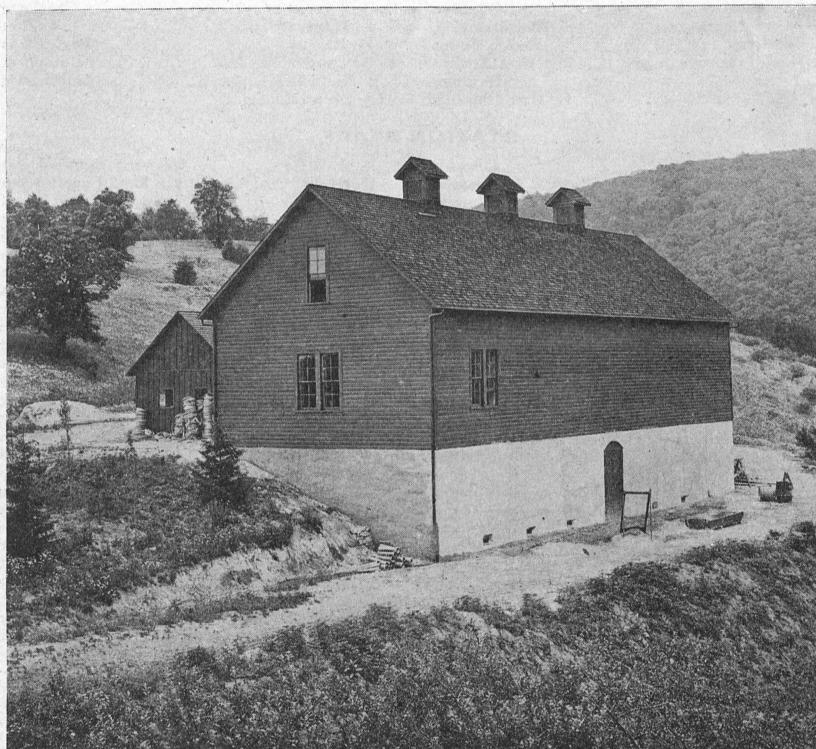
CONDUCTED JOINTLY BY THE

STATE DEPARTMENT OF AGRICULTURE

AND THE

COLLEGE OF AGRICULTURE AND MECHANIC ARTS

RALEIGH AND WEST RALEIGH



AIR-COOLED APPLE STORAGE HOUSES

BULLETINS OF THE STATION WILL BE SENT FREE TO CITIZENS OF THE STATE ON REQUEST

**THE NORTH CAROLINA  
AGRICULTURAL EXPERIMENT STATION**

CONDUCTED JOINTLY BY THE

**STATE DEPARTMENT OF AGRICULTURE**

AND THE

**N. C. COLLEGE OF AGRICULTURE AND MECHANIC ARTS**

**BOARD OF AGRICULTURE**

*W. A. GRAHAM,	<i>Chairman</i> , Raleigh.		
F. P. LATHAM.....	Bellhaven	*A. T. McCALLUM.....	Red Springs
K. W. BARNES.....	Lucama	*C. C. WRIGHT.....	Hunting Creek
*R. L. WOODARD.....	Pamlico	WILLIAM BLEDSOE.....	Gale
CLARENCE POE.....	Raleigh	W. J. SHUFORD.....	Hickory
*R. W. SCOTT.....	Haw River	A. CANNON.....	Horse Shoe

**BOARD OF TRUSTEES OF THE COLLEGE**

GOVERNOR LOCKE CRAIG, *Chairman*.

M. B. STICKLEY.....	Concord	*T. T. THORNE.....	Rocky Mount
T. T. BALLINGER.....	Troy	*C. W. GOLD.....	Greensboro
†N. B. BROUGHTON.....	Raleigh	T. E. VANN.....	Como
*O. L. CLARK.....	Clarkton	D. A. TOMPKINS.....	Charlotte
EVERETT THOMPSON.....	Elizabeth City	W. E. DANIEL.....	Weldon
R. H. RICKS.....	Rocky Mount	*W. H. RAGAN.....	High Point
O. MAX GARDNER.....	Shelby	W. B. COOPER.....	Wilmington
M. L. REED.....	Biltmore	J. P. MCRAE.....	Laurinburg
*D. H. HILL (President College), West Raleigh.			

**STATION STAFF**

B. W. KILGORE.....	Director	C. L. METCALF.....	Assistant Entomologist
C. B. WILLIAMS.....	Vice Director, Agronomist	A. R. RUSSELL.....	Assistant in Field Experiments
W. A. WITHERS.....	Chemist	R. Y. WINTERS.....	Agronomist in Crops
FRANKLIN SHERMAN, JR.....	Entomologist	W. F. PATE.....	Agronomist—Soils
W. N. HUTT.....	Horticulturist	E. C. BLAIR.....	Assistant Agronomist—Soils
G. A. ROBERTS.....	Veterinarian	*C. B. ROSS.....	Poultry Clubs
¹C. R. HUDSON.....	Farm Demonstration	E. S. DEWAR.....	Assistant Chemist
J. P. PILLSBURY.....	Horticulturist	R. G. HILL.....	Assistant Horticulturist
H. R. FULTON.....	Plant Diseases	*H. M. LYNDE.....	Drainage Engineer
Z. P. METCALF.....	Entomologist	I. J. M. JOHNSON.....	Farm Management
DAN T. GRAY.....	Animal Industry	F. R. BAKER.....	Assistant Drainage Engineer
T. H. TAYLOR.....	Acting Poultryman	A. L. FIELD.....	Assistant Chemist
W. R. CAMP.....	Marketing	R. O. CROMWELL.....	Assistant, Plant Diseases
J. M. PICKEL.....	Feed Chemist	*A. J. REED.....	Dairy Farming
W. G. HAYWOOD.....	Fertilizer Chemist	STANLEY COMBES.....	Assistant, Dairy Farming
L. L. BRINKLEY.....	Soil Survey	A. L. SHOOK.....	Assistant, Beef and Swine
S. B. SHAW.....	Assistant Horticulturist	W. C. NORTON.....	Assistant in Bacteriology
²W. E. HEARN.....	Soils	*T. E. BROWNE.....	Assistant in Charge Boys' Clubs
R. S. CURTIS.....	Associate in Animal Industry	A. K. ROBERTSON.....	Assistant in Boys' Clubs
J. L. BURGESS.....	Agronomist in Crops	*Mrs. C. MCKIMMON.....	Asst. in Charge Girls' Clubs
J. K. PLUMMER.....	Soil Chemist	Miss MARGARET SCOTT.....	Assistant in Girls' Clubs
S. C. CLAPP.....	Assistant Entomologist	R. C. JOURNEY.....	Soil Survey
W. H. EATON.....	Dairy Experimenter	E. B. HART.....	Assistant Chemist
G. M. GARREN.....	Assistant Agronomist in Crops	F. E. CARRUTH.....	Assistant Chemist
¹E. H. MATHEWSON.....	Tobacco Expert	J. R. MULLEN.....	Assistant Chemist
S. O. PERKINS.....	Soil Survey	Miss MARY S. BIRDSONG.....	Secretary to Director
J. Q. JACKSON.....	Assistant Chemist	A. F. BOWEN.....	Bursar
L. R. DETJEN.....	Assistant Horticulturist		
R. W. COLLETT.....			Assistant Director Branch Stations
F. T. M. EACHAM.....			Assistant Director Iredell Branch Station, Statesville
J. H. JEFFERIES.....			Assistant Director Pender Branch Station, Willard
F. N. McDOWELL.....			Assistant Director Edgecombe Branch Station, Rocky Mount
¹E. G. MOSS.....			Assistant Director Granville Branch Station, Oxford
F. S. PUCKETT.....			Assistant Director Buncombe and Transylvania Branch Stations, Swannanoa

The members marked with \* are members of the Joint Committee for Agricultural Work, and the Station is under their direction.

¹In coöperation with the U. S. Department of Agriculture, Bureau of Plant Industry.

²In coöperation with the U. S. Department of Agriculture, Bureau of Soils.

³In coöperation with the U. S. Department of Agriculture, Bureau of Animal Industry.

⁴In coöperation with the U. S. Department of Agriculture, Office of Experiment Stations.

†Deceased.

## AIR-COOLED APPLE STORAGE HOUSES.

---

BY W. N. HUTT.

---

As soon as apple growing has reached commercial proportions the demand for some kind of storage becomes imperative. Even with most favorable markets, it is seldom at harvest-time that fruit can be sold to advantage. At that time of year there is generally such a large amount of early fruit that must find an immediate market that the highest grade fruit, and especially long-keeping sorts, are sacrificed if they have to be sold at picking time. Furthermore, there is always a greater or less proportion of cull or defective fruit as the result of sorting and grading that gluts the market at harvest-time and depresses the demand for better fruit. Very often, a month or two later, when the harvest glut is over, there is a shortage of fruit, with attendant high prices. In the oldest and best developed commercial fruit regions the utilization of modern methods of cold storage has been the means of saving to the growers immense amounts of fruit that would otherwise have been lost or sacrificed on an overstocked market. In this way cold storage has had an important influence in encouraging the development of commercial fruit culture and in establishing it as a stable industry.

If the ideal storage were available it would certainly be one or other of the methods of mechanical refrigeration which modern engineering skill has of late brought to such a high degree of perfection. Owing, however, to the high cost of construction and installation of such plants, and the fact that to pay they must be operated the year round, they are practically beyond the reach of the average farmer and fruit grower. Even ice-cooled storage houses are usually impracticable except where handled by coöperative organizations or fruit exchanges.

Several times in the last few years my attention has been called to remarkably fine fruit being put on the market late in the season by mountain farmers. These apples had been kept in various kinds of cellars and caves, and were almost as sound and firm as the fruit coming from cold storage. One old man used to come over from the Blue Ridge Mountains bringing with him, on the same load, apples of this and of last season's crop. This led me to investigate the subject of cellar or common storage, with the idea of designing a cheap apple-storage house that would enable our mountain growers to hold over their good fruit until it could find a profitable market. In the meantime some of our most progressive growers had already constructed different forms of air-cooled storage houses and had used them for one or two seasons. Observations were made on these houses, and the two first constructed were equipped with self-recording hygro-thermographs, so as to keep a com-

plete record of temperature and moisture changes within the house during the entire storage period. It was owing to the high cost of these delicate instruments that it was not possible to keep records on all the houses under observation.

The storage house which is practicable for the average fruit grower must necessarily be some form of air-cooled house of sufficiently inexpensive construction that he can afford to use it for storage only during the winter months. Such a house may be placed in the orchard or at some convenient point where it can serve also as packing house and storage for boxes and barrels.

An air-cooled storage, since it depends for its efficiency on the use of cold air, can be operated advantageously only in latitudes where outside winter temperatures are fairly cold and constant. It stands to reason that they would not work in the mild winter climate of the far south. They have, however, proved themselves very efficient in the northern States and in Canada. In the apple regions of our southern mountains, where the high altitude gives a climate similar to that of the northern States, they have also given good results.

#### MATERIALS FOR STORAGE-HOUSE CONSTRUCTION.

The efficiency of any form of fruit storage house depends on the insulating of a chamber with walls of such materials and of sufficient thickness so that the temperature within will be affected as little as possible by fluctuations of temperature without. Wood is a good non-conductor of heat and makes an excellent material for the construction of storage houses, except for its lack of durability. Stone is not nearly such a good nonconductor as wood, but as it makes a practically indestructible building, it is a material frequently used in the construction of fruit storage houses. On many orchards the rocks that impede cultivation and break up farm machinery find a very useful and convenient place in the construction of an orchard storage house. Brick is a better insulating material than stone, and where obtainable at reasonable prices makes one of the very best and most convenient materials for this purpose. Cement concrete, now so much used for every sort of permanent building, is probably the most common, if not the best, material for the construction of storage houses. Cement construction has the advantage that it makes a dry wall that does not harbor moisture. All sorts of waste and useless stone can be worked in, and yet when completed all surfaces may be smooth and clean. Cement structures may be easily, quickly, and perfectly built by cheap and unskilled labor.

The foregoing discussion of structural materials for storage houses has not mentioned the two best and cheapest insulating substances, viz., earth and air. - Ever since the days of the "dugout" it has been known that soil is very slowly affected by changes of heat and cold, and is therefore one of the best materials for insulating against widely fluctuating

external temperatures. Air in a still or "dead" condition is the best of all the nonconductors of heat. The most perfect storage chambers are merely a series of structures to maintain a succession of dead-air blankets. Air is the best insulating substance, but its value depends on its stillness. If it is free to move in spaces of considerable size it will be in almost constant circulation, thereby causing convection currents which will carry outside heat into the storage chamber. Air spaces, therefore, should be narrow rather than deep, and should be built so tight that the air will be in the dead or still condition that makes it the best insulating medium. Chaff, chopped straw, sawdust, tan-bark, shavings, etc., on account of the air they contain, are good insulating materials, but they soon absorb moisture and decay in a comparatively short time. Quilts of various materials, such as hair, felt, mineral wool, flax fiber, and eel-grass, on account of the finely divided air they contain, make valuable materials for lining doors and also the walls of storage chambers. In the construction of inexpensive but efficient orchard storage houses it is our purpose to avail ourselves as far as possible of the use of earth and dead air. In furthering this end the hilly land of the apple region can supply a good insulating medium on practically three sides by having the first story of the house built deep into a hillside. The exposed side of the house should face the north, where it avoids the direct sun in the daytime and draws in the coldest air at night. The second story will be insulated by having hollow walls so as to afford one or more dead-air spaces.

#### DOORS AND WINDOWS.

Apertures for ventilation and the intake of cold air are necessary for air-cooled storage houses, but windows and doors should be reduced to the smallest possible number and size consistent with convenience. It is through the windows and the doors that most of the injurious rises in temperature gain access to the fruit. If electric light can be installed, there is practically no necessity of windows for lighting the storage chambers. If windows must be used, make them no larger than necessary, have the sashes fit very snug, and have one or more dead-air spaces between sashes. In all ordinary cases one door is sufficient both for putting in and taking out fruit. The doors of storage houses should be double thick, lined with builders' paper and filled with sawdust or some other suitable insulating material. Two such doors should be fitted so as to secure a dead-air space between them. The dead-air spaces between doors and windows and also in walls should not be over 2 inches deep. If air spaces are made larger, convection currents readily set up and carry heat into the storage chamber.

Figure 1 illustrates an air-cooled apple storage house built by Mr. J. R. Sams, Mars Hill, N. C., in the autumn of 1912. On March 17, 1913, Mr. Sams sent me by parcel post Stayman apples that had been

kept in this house. The apples were very large, having been grown on young trees, but they were in prime condition at that time. The varieties Delicious and Chicago were in good plump condition on May 9, 1913. Ben Davis and Black Bens kept up to June.

Figure 3 shows the ground floor plan of Mr. Sams' storage house. Figure 4 shows the plan of the second story.

The following are detailed specifications of construction:

"Built of first-class brick, tile drained around foundations. Double walls constructed of two layers of brick each, with dead-air space of 2 inches between walls. Storage chambers 32' x 16' x 8', capacity 400 bar-

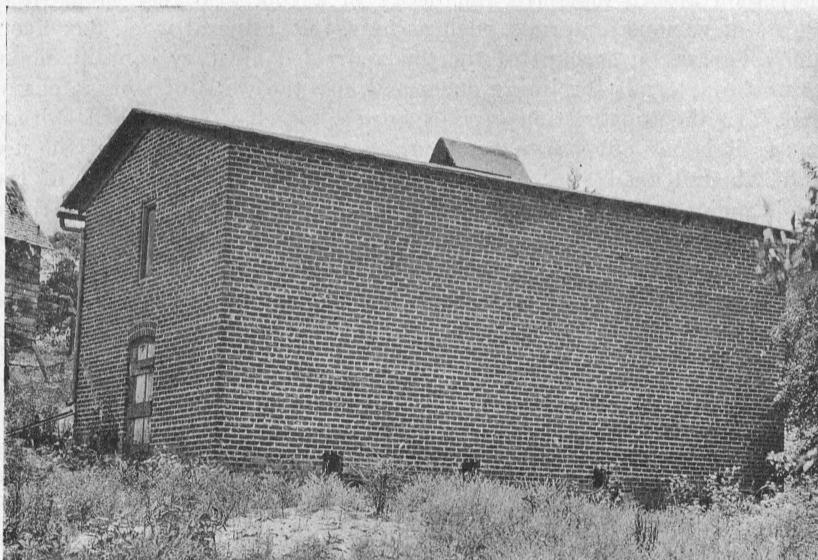


FIG. 1. Apple storage house of Mr. J. R. Sams, Mars Hill, N. C.

rels each. Three-foot double doors at east end of lower story. Four 9 x 9-inch ventilators on north side. Ventilators are plugged in hot and very cold weather with paper-lined, sawdust-filled plugs, as shown in Figure 2. Dirt floors with scantlings to support barrels.

"Upper story same dimensions as lower. Solid plank floor with slatted portions 15" wide of 1" x 2" strips  $\frac{5}{8}$ " apart to allow for passage of air from lower story. Four flues below top joists with cover to regulate circulation of air connect with hooded flue at top of house. Small double windows in each end. Double-door entrance from roadway on south side. Spaces between joists on top of second story packed with 10 inches of sawdust."

This house was built for \$600.

Figures 5, 6, 7, and 8 show the storage house of Mr. R. N. Barber of Waynesville, N. C. This house, 80' x 30' inside measurement, is built of rock masonry and plastered inside with cement. It is two stories high. The lower story is designed for fruit storage, while the room above is used for storage of cooperage stock and implements. The walls are of solid masonry 33 inches thick. The floor and ceiling of the apple storage chamber are of concrete 5 inches thick, the latter reinforced with railroad iron, rods, and woven wire. The only entrance to the storage chamber is through an 8' x 7' sawdust-filled door. The south side of the house sits in a hill, the earth insulating the entire height of the lower story. The north wall of the apple storage chamber is pierced with five windows. Each window has two sets of sash affording dead-air space between. A double-boarded, paper-lined shutter closes tightly over each window. The ventilating system of this house consists of three parallel concrete air ducts running the length of the building. The intakes,



FIG. 2. Air intakes and plugs of Mr. J. R. Sams' apple storage house.

2' x 2' x 2', constructed of brick, form vertical wells which connect through the wall with the air ducts. The ducts are 12" x 12" inside measure and deliver air through wire-screened openings 6" x 10" at intervals of 5 feet. The air passes to the chamber above through similar openings in overhead ducts. See Figure 8. The flow of air through the house is controlled by plugs made to fit the openings. The capacity of the apple storage chamber is 2,800 barrels. Mammoth Blacktwig, Delicious, and Stayman apples kept satisfactorily in this house until May.

The storage house of Mrs. Moses Cone, Blowing Rock, N. C., shown in the frontispiece and in Figures 9, 10, and 11, is of three stories. The basement, 77' x 25' x 11' inside measurement, has a solid masonry wall 20 inches thick, plastered with cement inside and out. This chamber has a capacity of 2,000 barrels. It has a 6-inch cement floor. The south side of the basement sits into a hill almost to the level of the second floor. Air is admitted to the storage chamber through openings 6" x 12" placed 8" above the level of the floor. These openings have double air-tight shutters to control the flow of air into the chamber.

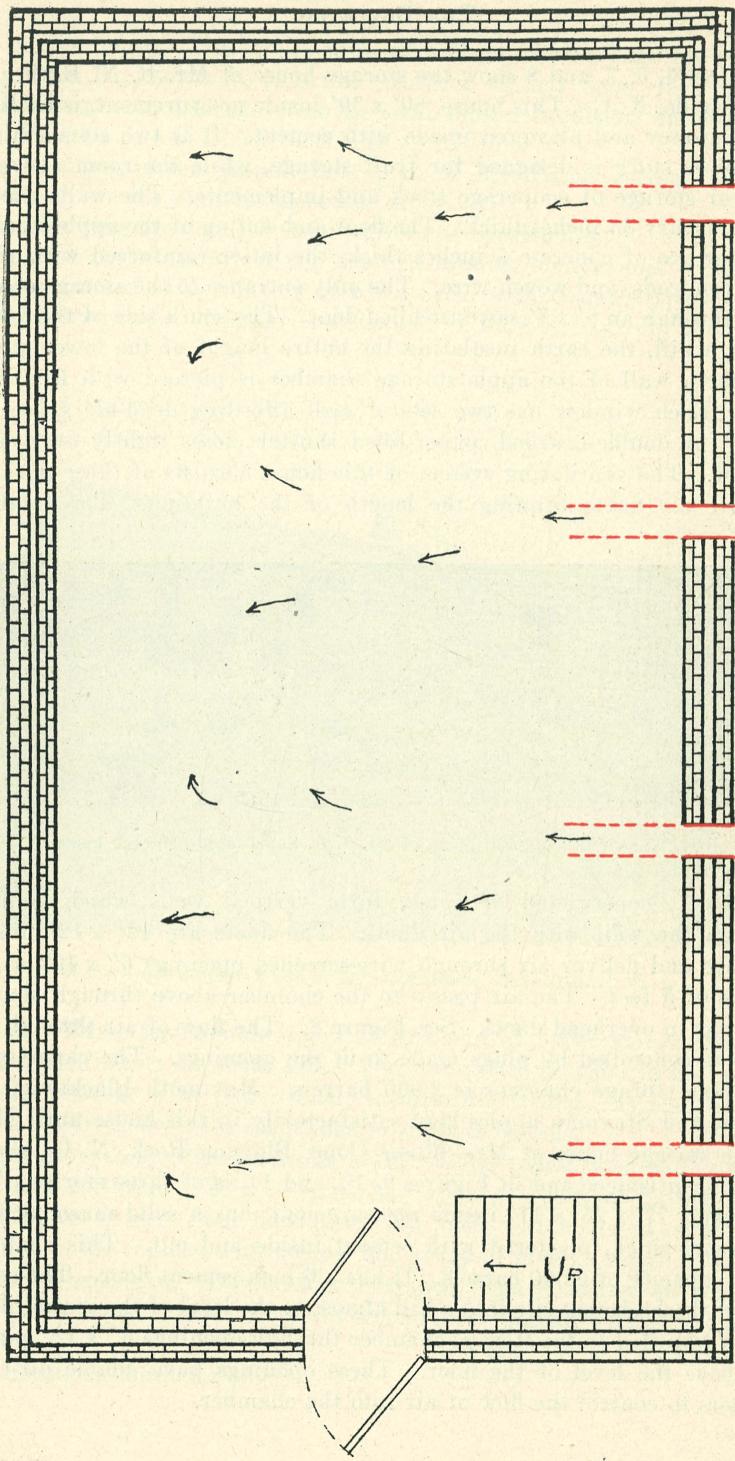


FIG. 3. Ground floor of Mr. J. R. Sams' apple storage house, showing ventilating system.

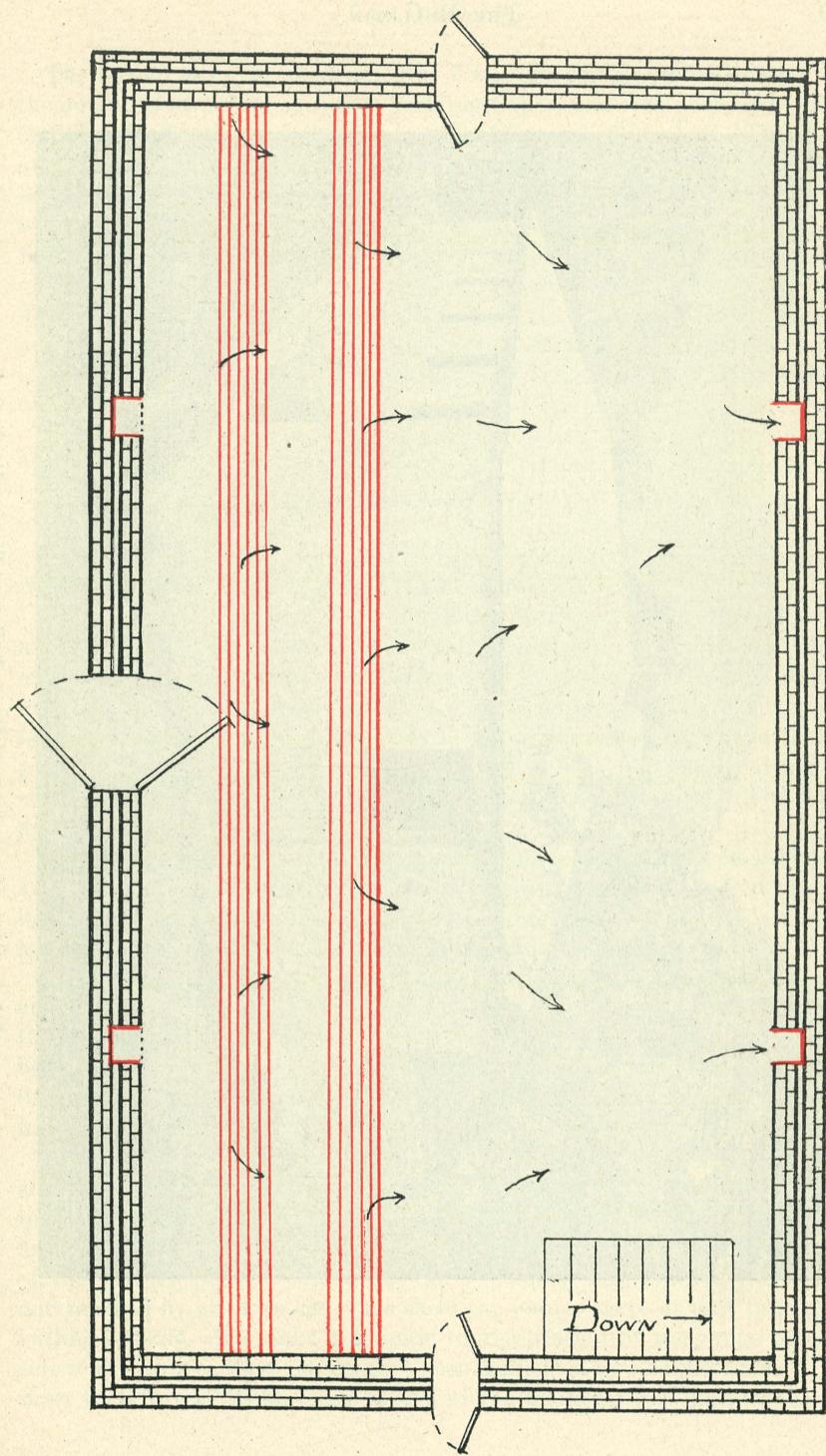


FIG. 4. Upper story of Mr. J. R. Sams' apple storage house, showing ventilation through slatted portion of floor.

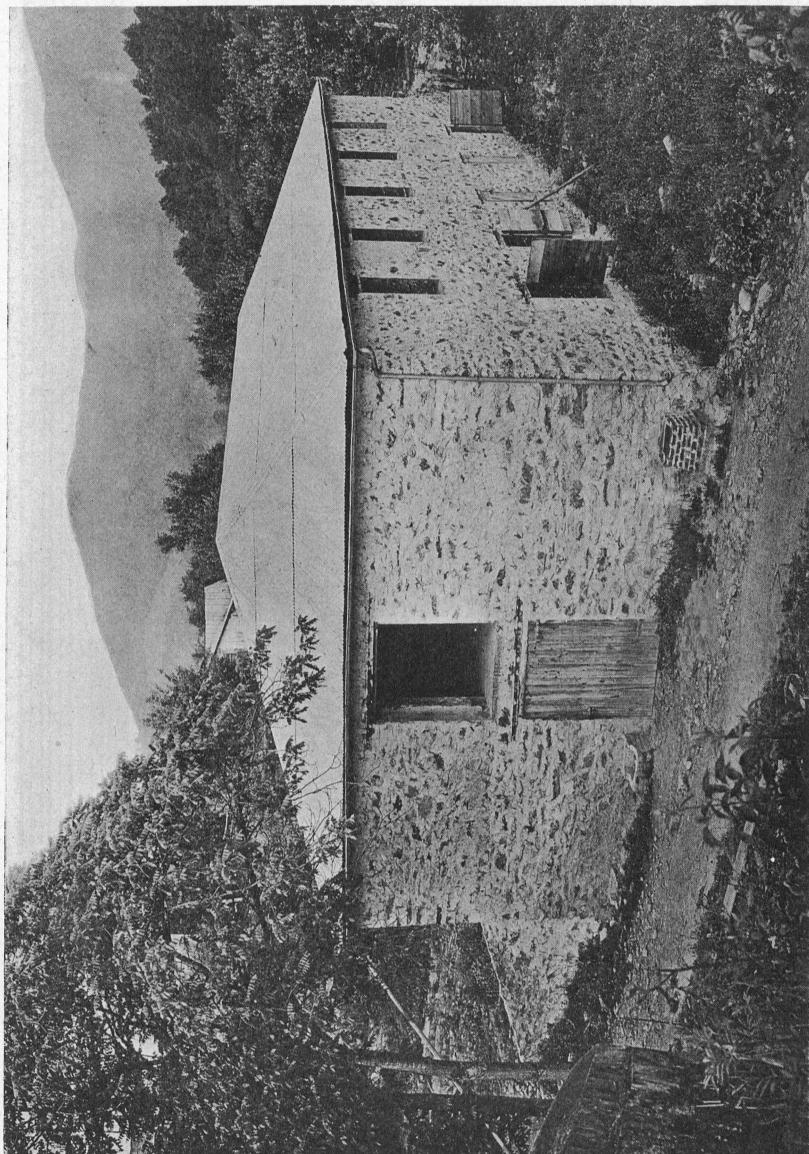


FIG. 5. Apple storage house of Mr. R. N. Barber, Waynesville, N. C.

The second story is constructed of 2 x 10 studding, double-boarded on the outside with storm sheeting, building paper, and weatherboard. The studding is sheathed on the inside with 1" matched lumber. The floor of the second story is of single thickness laid on 2" x 10" joists, 18" center between joists. The ceiling of this room is of similar construction with the walls. This room is designed as subsidiary storage. Twenty feet of it is cut off as a packing room, which has an elevator to the basement. The third story is a loft to accommodate packing materials. Three ventilators through the roof are connected by 18" x 18" air shafts, with similar openings in the ceiling of the second story. This draws the air from the basement through openings of the same size in the ceiling of the second floor. The openings are fitted with light, adjustable covers.

The materials used in the construction of this house are as follows: 40,000 feet lumber, 32 cubic yards stone, 460 sacks cement, 30 rolls building paper, 35 rolls roofing paper. Rough lumber cost \$10 per M, weatherboard and flooring \$20 per M.

Figures 12, 13, 14, and 15 illustrate the storage house of the Gold Medal Orchards of Oakwoods, Wilkes County, N. C.

The house is of two stories. The lower story, which is especially designed as the apple storage chamber, is placed deep in a hillside. The ends and part of the front are flanked with loose rock walls so as to give an almost complete earth insulation. See Figure 14. The lower story is entered from a road on the north, while the chamber above is approached by a road on the south side. The walls of the basement are of cement concrete and double so as to afford a dead-air space. The floor and ceiling are also of cement.

The upper story is of double wooden walls with air space between. It is designed as a subsidiary storage in case of extra crop, and is also used as a packing room and storage of boxes and barrels. All windows and doors are constructed so as to afford air insulation.

The ventilation system of this house consists of a box air duct which enters from the north side below the door and branches to four openings through the floor near the rear wall. The air is released from this chamber through two large capped vents in the ceiling above. When the damper in the air duct is opened the inrush of cool air will draw in a handkerchief held over the opening.

A self-recording instrument was placed in this house early in the storage period and a complete record of temperature and humidity kept until the last of the crop was disposed of on April 28th. Figure 16 is an illustration of the hygro-thermograph trace sheet for an average week of the storage period. Each day at 6 a. m. a man entered the house and marked by an X on the trace sheet the temperature at that time prevailing outside. To make a graphic representation of the range of outside temperatures these points have been connected by straight lines. The sheet therefore gives an exact record of the temperatures maintained by

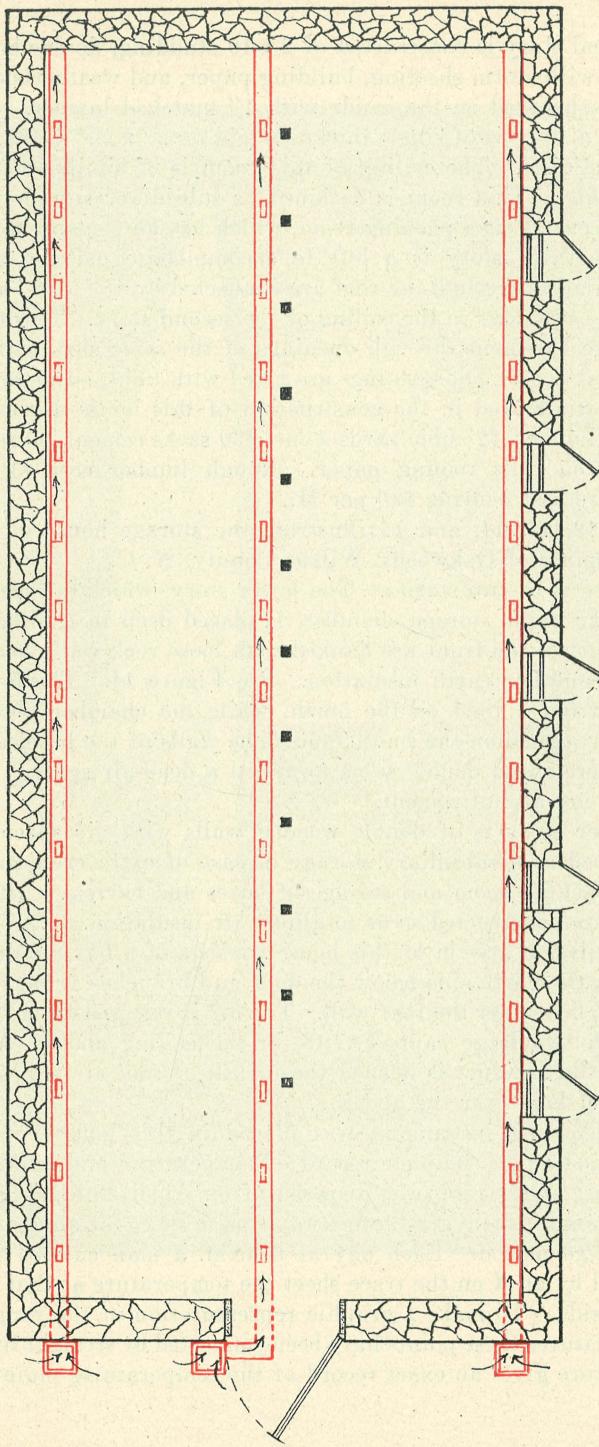


FIG. 6. Storage chamber of Mr. R. N. Barber's apple house, showing ventilating ducts.

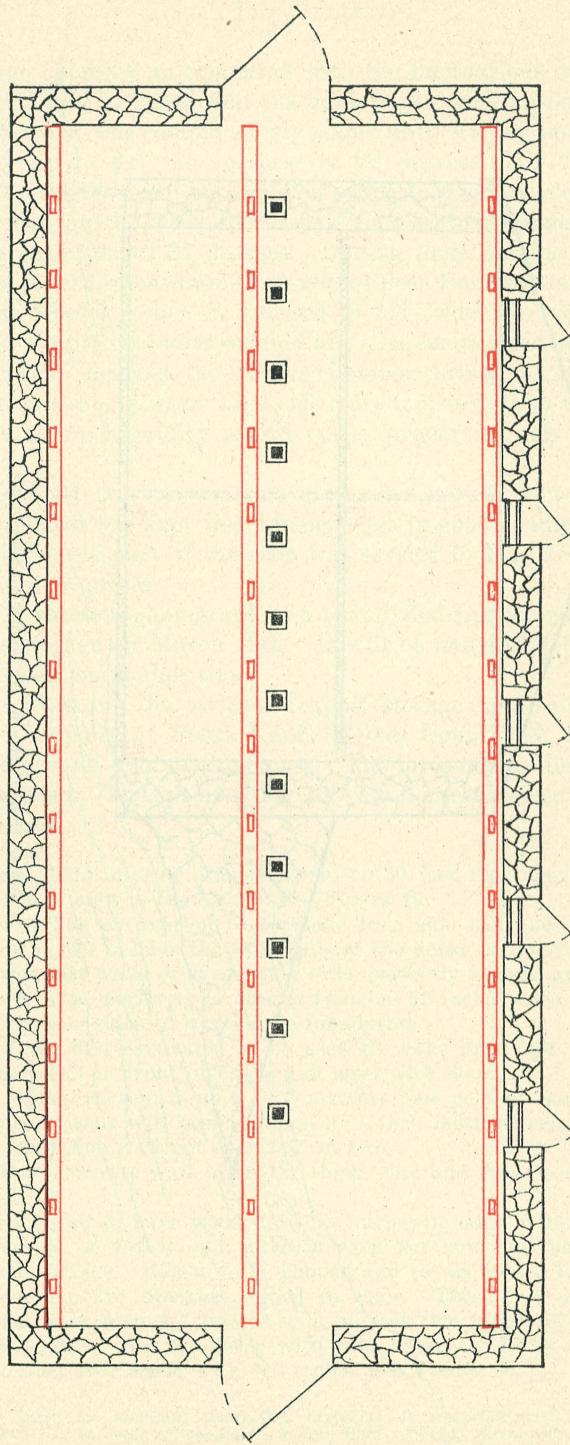


FIG. 7. Second story of Mr. R. N. Barber's apple house.

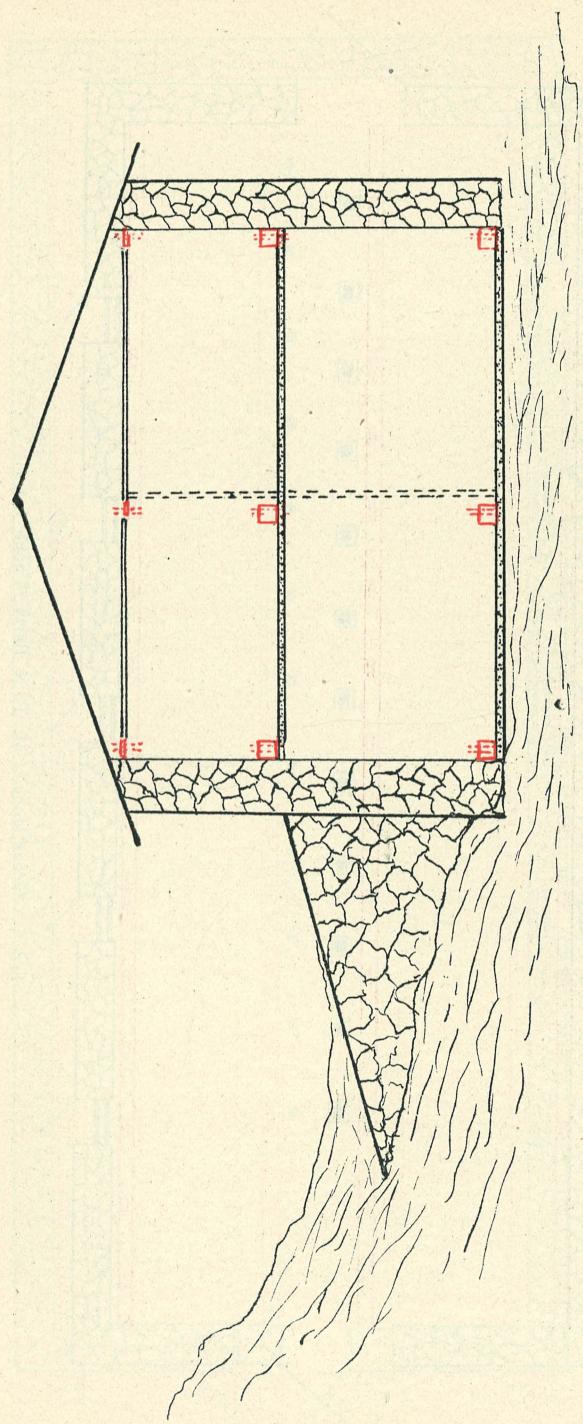


FIG. 8. Cross-section of Mr. R. N. Barber's apple house.

the storage chamber as compared with the fluctuations of temperatures outside. It will be noted that the week began with an outside temperature of 39° and was comparatively stable until Friday morning, when it ran away up to 61°, an increase of 22 degrees. By Sunday it had dropped 13 degrees, and on Monday, owing to a cold wave, it went down to 24°. During the week the outside temperature ranged from 61° to 24° or a variation of 37 degrees. During these outside variations the inside temperature maintained an almost even line from 42° on Tuesday to 48° on Sunday, when it dropped to 37°, when the ventilators were opened to admit the cooler outside air. In comparison with an outside variation of 37 degrees, the storage chamber showed a total variation of only 11 degrees. As warm air holds more moisture than cold air, it will be seen that the humidity record varies proportionately with the temperature.

For the past two seasons this air-cooled storage house of the Gold Medal Orchards has kept Red Limbertwigs in good condition up to May 1st. This year a part of the crop was carried to May 15th and sold at very handsome prices.

Figure 17 shows a photograph of a box of Red Limbertwig apples taken from this storage on March 12th. It will be noted that they are in the pink of condition at that time.

Figure 18 shows the air-cooled apple storage house of the Triangle Orchard Company at Poors Knob, Wilkes County, N. C. Figure 19 shows the ground plan of this house. The broken lines indicate the ventilating system. The specifications of this house as given by the owners are as follows:

*Dimensions.*—The interior dimensions to be 30 feet frontage by 20 feet deep by 9 feet high in the clear. See Figure 19.

*Excavation.*—The excavation to be made in a side hill and sufficiently deep into the hill to have the side walls of the house well covered with dirt.

The three dirt walls of excavation to be perfectly smooth and plumb.

The floor to be perfectly level, and trenches 12 inches deep to be excavated on all four sides to receive the foundation.

Part of the dirt excavated to be used to make an 8-foot wide fill (faced with rock) in front of house and level with floor.

*Concrete.*—The concrete to be a 1-3-5 mixture, one part of cement, 3 of clean-cut sand that will pass through a  $\frac{1}{4}$ -inch mesh screen, and 5 parts of sharp broken rock not over  $2\frac{1}{2}$ " in size.

*Walls.*—Rear concrete wall to be 12" thick, side and front concrete walls 16" thick.

The front wall to have wooden blocks buried in same at regular horizontal intervals of 4 feet and three in each per row and placed flush with inner surface. Blocks to be shaped and set as shown in Figure 20 and to receive 2x4 uprights nailed to same. These 2x4 pieces are to be ceiled over with  $\frac{3}{4}$ " boards, and on this two layers of Cabot's Double Ply "Quilt"\*\* laid crosswise with each other are to be nailed. This to be ceiled over again with  $\frac{3}{4}$ " stuff. See Figure 20.

\*Cabot's quilt, an excellent insulating material, is manufactured by Samuel Cabot, Boston, Mass. It is made of eel-grass, a long fiber of great durability and resistance to fire. Being a sea plant and containing a large per cent of iodine, it is therefore a repellent to rats and vermin.

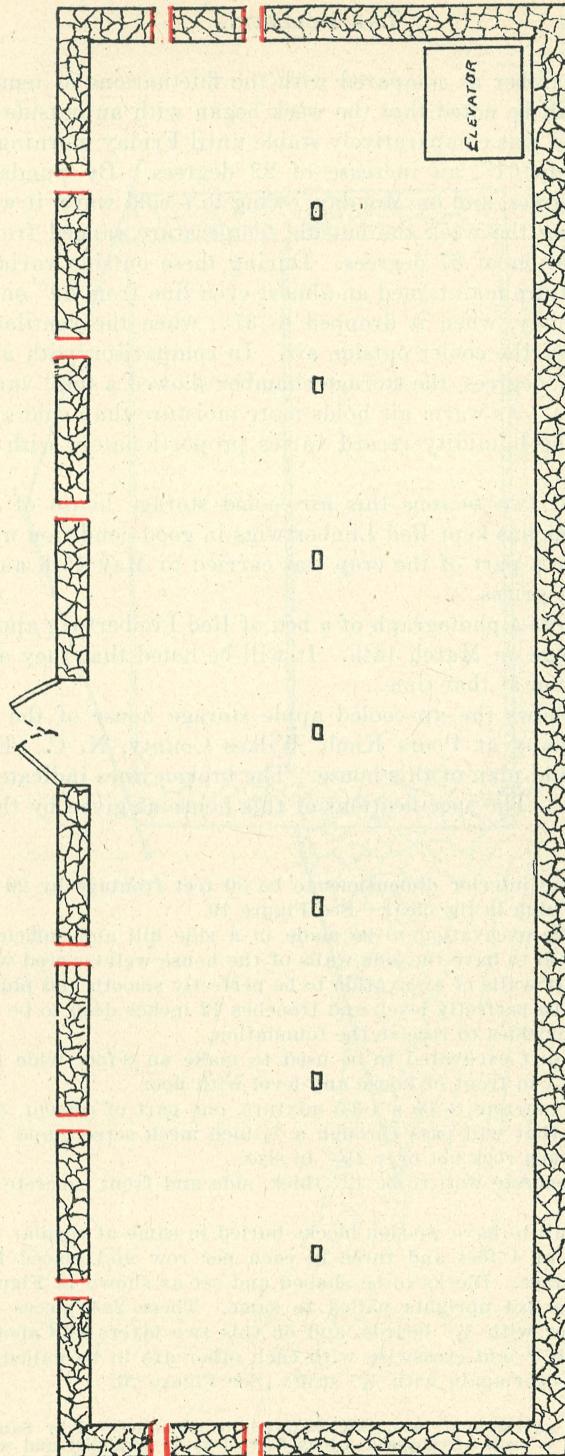


FIG. 9. Storage chamber of Mrs. Moses Cone's apple house at Blowing Rock, N. C.

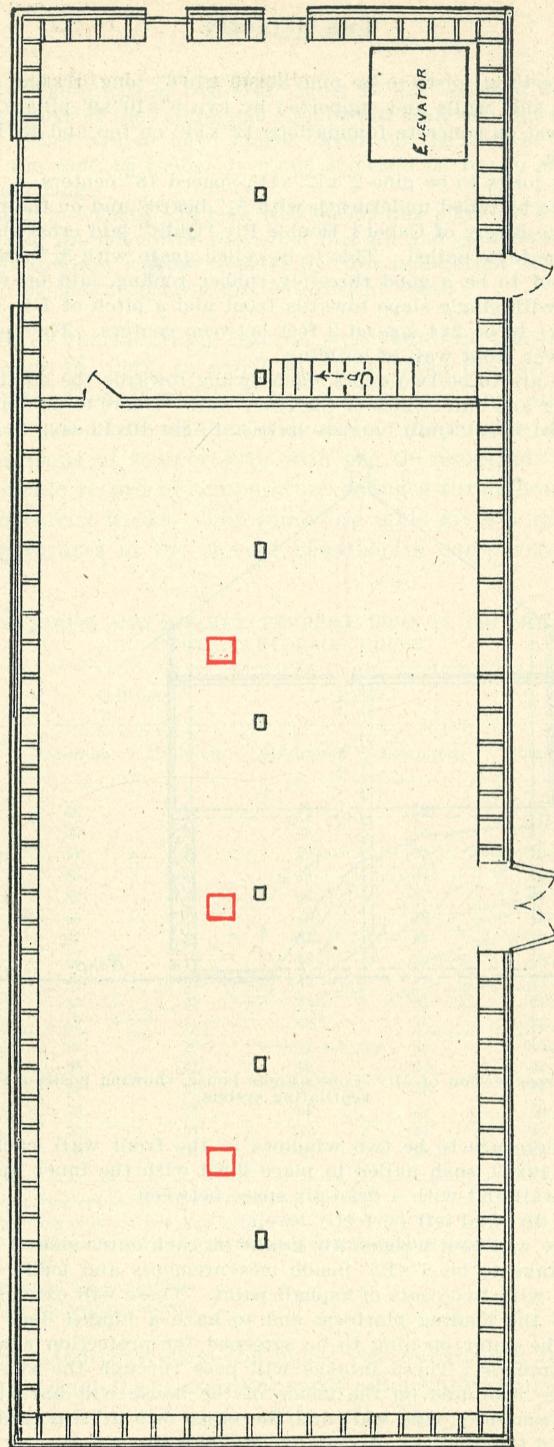


FIG. 10. Packing-room and subsidiary storage chamber of Mrs. Moses Cone's apple house.

*Ceiling.*—The ceiling joists to be pine 8"x10"x10'6" long, resting on center of the two side walls and supported by two 8"x10"x9' pillars. These latter to rest on concrete foundations 12"x14" on top and 18"x20" on base 14" high.

The ceiling joists to be pine 2"x12"x11', spaced 18" centers.

These are to be ceiled underneath with  $\frac{3}{4}$ " boards and on the under side of them two layers of Cabot's Double Ply "Quilt" laid crosswise with each other are to be nailed. This to be ceiled again with  $\frac{3}{4}$ " stuff.

*Roof.*—The roof to be a good three-ply rubber roofing, laid on well matched boards with single slope towards front and a pitch of 1 in 4. The roof (rafters) to be 2x4 spaced 2 feet between centers. The roof to extend 4 feet over front wall of building.

*Doors.*—There are to be two doors, each swung towards the outside and from the inner and outer sides of the front wall. Doors to be double boarded, interlined with "Quilt" and to have a 4-light 10x12 sash in each.

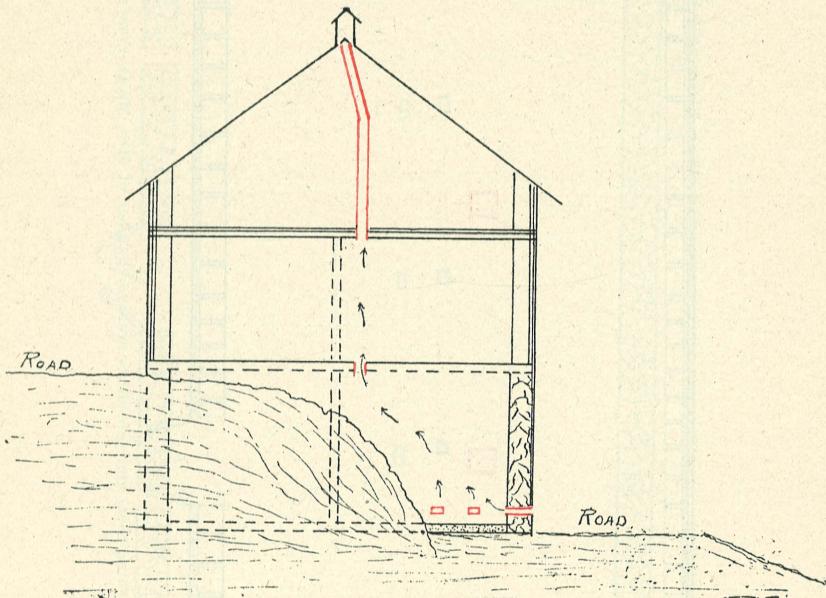


FIG. 11. Cross-section of Mrs. Cone's apple house, showing position in hill and ventilating system.

*Windows.*—There are to be two windows in the front wall, each window to be two 10x12, sash nailed in place flush with the inner and outer side of the wall and with a dead-air space between.

*Floor.*—To be dirt and left perfectly level.

*Intake.*—There will be a wooden air intake on each outer side of the building, said intake to be 8"x12" inside measurements and made of 2x12 pine painted with two coats of asphalt paint. These will extend to the outer edge of the loading platform and to have a hinged door swung from top. The outer opening to be screened for protection against mice or other animals. These intakes will pass through the side walls flush with the floor and on the inside of the house will have three outlets, one at center of side wall and the other two at rear and front walls one-third the distance of same from side wall.

*Draft Tubes.*—There will be two draft tubes 12"x24" each in the clear placed in the center of the ceiling and equidistant from the end walls and each other. They are to have hinged doors on the bottom, extend 4 feet above the roof, be roofed over and screened on top to prevent animals from entering.

*Loading Platform.*—There will be a wooden loading platform 6 feet wide running from the door over the 8-foot dirt fill and protruding 12 feet over this fill, to allow wagons to drive up close and permit of easy loading.

*Rubblewall.*—At ends to protect dirt covering at sides.

Very careful thermograph records were kept in this storage house from December 16, 1913, to April 20, 1914, when the last load of fruit was sold. Standard Weather Bureau maximum and minimum thermometers were used both on the inside and on the outside of the house to make comparisons of temperature with the thermograph inside. This gave an accurate record of temperature changes throughout the storage period of seventeen weeks. The following table gives a record by week of the temperatures in the storage chamber in comparison with those outside:

RECORD OF MAXIMUM AND MINIMUM TEMPERATURES AT TRIANGLE ORCHARD COMPANY STORAGE HOUSE.

Week Ending	Outside.		Inside.		Variations.	
	Maximum.	Minimum.	Maximum.	Minimum.	Outside.	Inside.
Dec. 21-----	58	28	46	38	30	8
" 29-----	59	21	46	38	48	8
Jan. 4-----	41	29	39	37	12	2
" 11-----	63	21	44	38	42	6
" 18-----	57	16	43	37	41	6
" 25-----	65	23	46	38	42	8
Feb. 1-----	68	29	52	40	39	12
" 8-----	65	19	48	39	46	9
" 15-----	48	16	42	37	32	5
" 22-----	57	14	45	37	43	8
Mar. 1-----	55	14	43	35	41	8
" 8-----	62	16	41	35	46	6
" 15-----	56	22	40	34	34	6
" 22-----	68	21	57	36	47	11
" 29-----	79	23	52	35	56	17
Apr. 5-----	70	31	52	41	39	11
" 12-----	70	31	52	38	39	14

<sup>1</sup>Several men sorting apples in house; weather hot outside.

<sup>2</sup>Carpenter working in house, left door open.

<sup>3</sup>A couple of hot days and five men in house packing and shipping apples.

<sup>4</sup>Working in house.

<sup>5</sup>Warm weather and taking out fruit.

<sup>6</sup>Warm weather and taking out fruit.

It will be noted that when the house was not opened for packing or shipping fruit, that the temperature was remarkably uniform, not varying over 8 degrees for the week, while at the same time the outside tem-

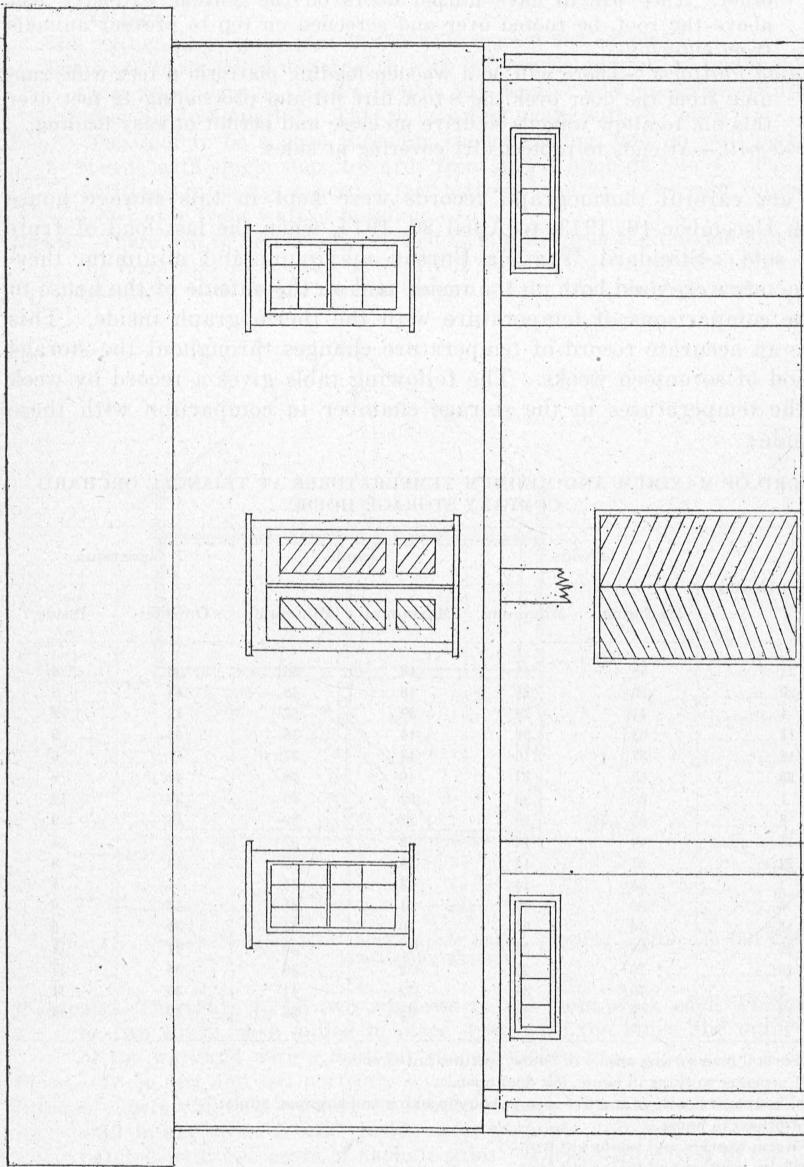


FIG. 12. North elevation of Gold Medal Orchards' apple storage house at Oakwoods, N. C.

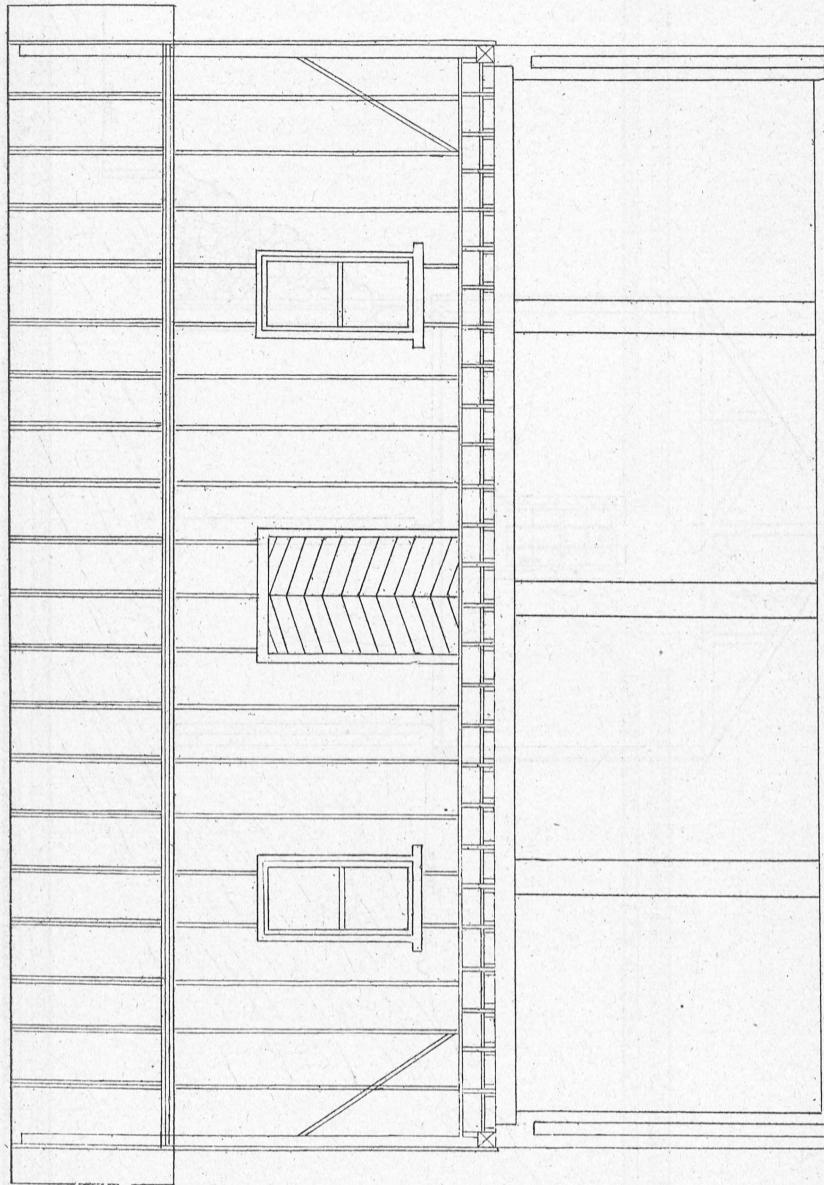


FIG. 13. South elevation of Gold Medal Orchards' apple storage house.

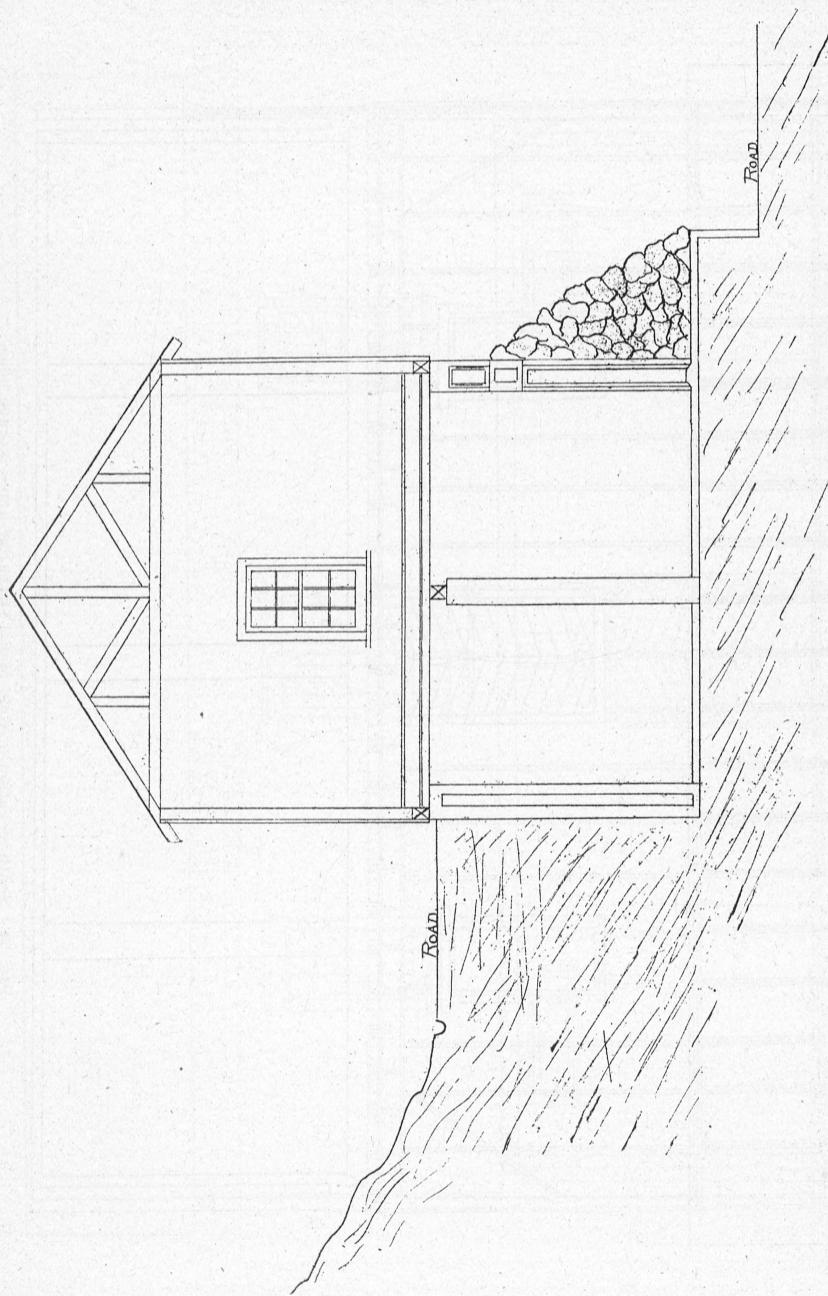


FIG. 14. Cross-section of Gold Medal Orchards' apple storage house, showing earth insulation and position of roads.

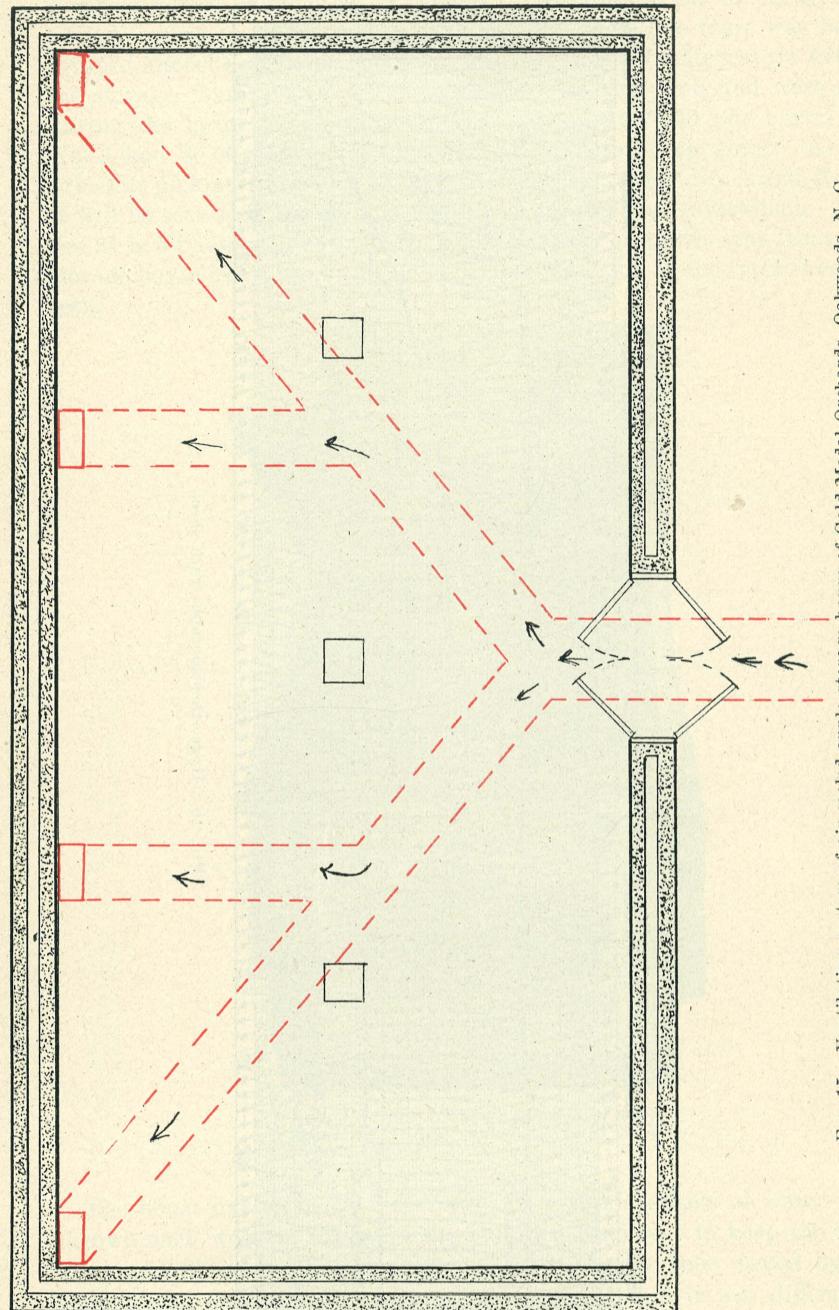


FIG. 15. Ventilating system of air-cooled apple storage house of Gold Medal Orchards, Oakwoods, N. C.

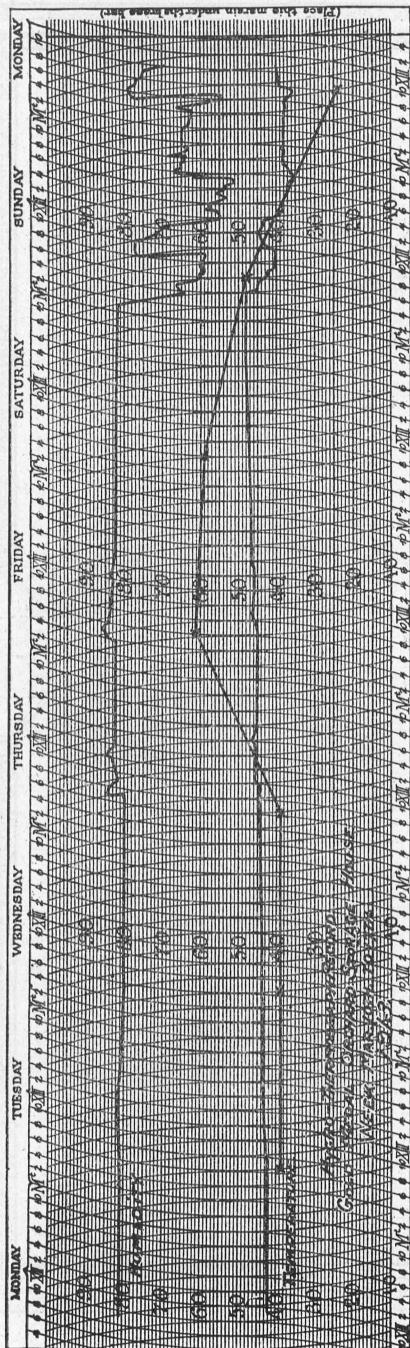


FIG. 16. Hygro-thermograph trace sheet.

perature varied as much as 48 degrees. Towards the end of the storage period, owing to warm spring days and the fact that fruit was being shipped almost every day, there was a marked rise in temperature within the storage chamber. Red Limbertwig apples kept well and were sold during the latter weeks of the storage period at \$6.50 per barrel for No. 1 and \$5.50 per barrel for No. 2, f. o. b. shipping point. As the prices at picking time were \$3 and \$2.50 per barrel for No. 1 and No. 2, it will be seen that the storage house was an excellent investment. Figure 21 is a photograph of a parcels post package of apples sent from this storage house February 25th. The perfect condition of the fruit is easily seen.



FIG. 17. Box of Red Limbertwig apples taken from storage house of Gold Medal Orchards, March 12, 1914.

The house has an earth floor on which several buckets of water were thrown each week to maintain the humidity sufficient to keep the fruit crisp and plump. The storage house with cement floor owned by the Gold Medal Orchards was found to be too dry, and it was difficult to keep the fruit from shriveling.

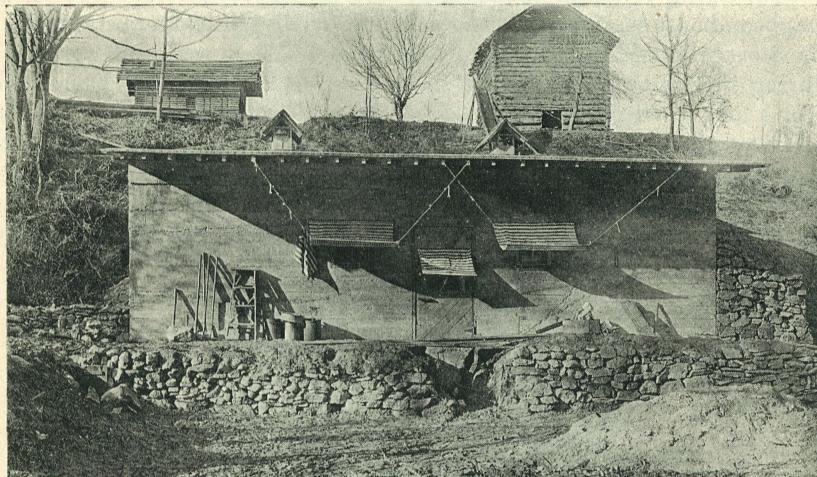


FIG. 18. Air-cooled apple storage house of Triangle Orchard Company,  
Poors Knob, N. C.

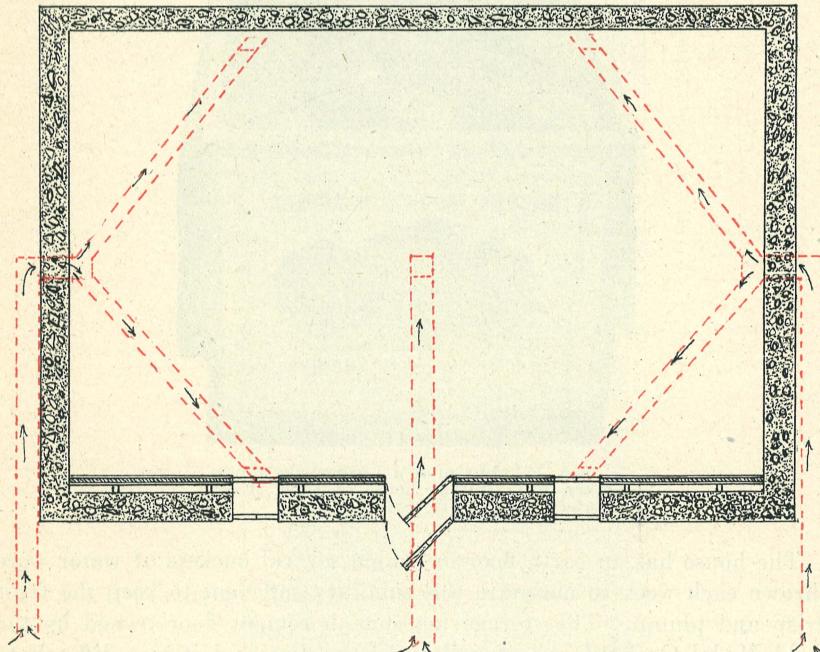


FIG. 19. Plan of storage chamber of apple house of Triangle Orchard Company,  
showing construction of walls and ventilating system.

## MATURITY OF APPLES FOR STORAGE.

Apples when ready for picking should be fully grown and highly colored. This is known to the grower as the "hard ripe" stage. If on lifting an apple it snaps off from the twig without breaking the stem, it is ready for picking. If left longer on the trees there will be danger of loss from overripes and windfalls. In picking apples, they should not be separated from the twig by a straight pull, but a nip upwards or sideways will remove the fruit from the twig without breaking or tearing out the stem.

Pears should be picked from the trees in a more immature stage than apples. They should be of full size, but entirely green and showing none of the yellow color. The separation of the stem from the twig, as with the apple, is a good test of picking condition with pears.

## MANAGEMENT OF AN AIR-COOLED APPLE STORAGE HOUSE.

It is without doubt of great importance to have a storage chamber well constructed to secure as perfect insulation as possible. It is, however, even more important to have such a house carefully handled to secure a cool and constant temperature. It is notable in practical cold-storage work that a good house poorly handled cannot compete with an inferior house well handled.

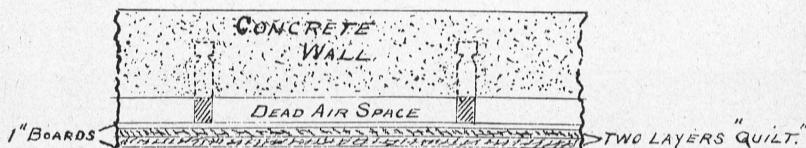


FIG. 20. Detail construction of wall of Triangle Orchard Company's apple storage house.

In preparation for the crop, advantage should be taken of every cool night to reduce the temperature of the storage chamber as low as possible. The ventilators should be opened after sundown and the whole house closed tightly before sunup so as to keep out the warm day air. If the house has been used for storage before, the interior and all boxes and barrels except new ones should be thoroughly sprayed with Bordeaux mixture. This will destroy all germs of decay that may have been carried over from last year's crop. Each day as the fruit is picked it should be placed in boxes or barrels and hauled to the packing house. It should not be put in the packing house in the evening, but left outside to cool down in the night air, and be put in the house before sunup in the morning. This practice will greatly conserve the cool temperature of the house and also keep the fruit from sweating in storage. As the weather

becomes cooler, advantage should be taken of it to lower the temperature and cool down the fruit as much as possible. When all the fruit is in, the house should be opened as little as possible and the fruit left wholly undisturbed. Practical cold-storage men differ as to what is the proper

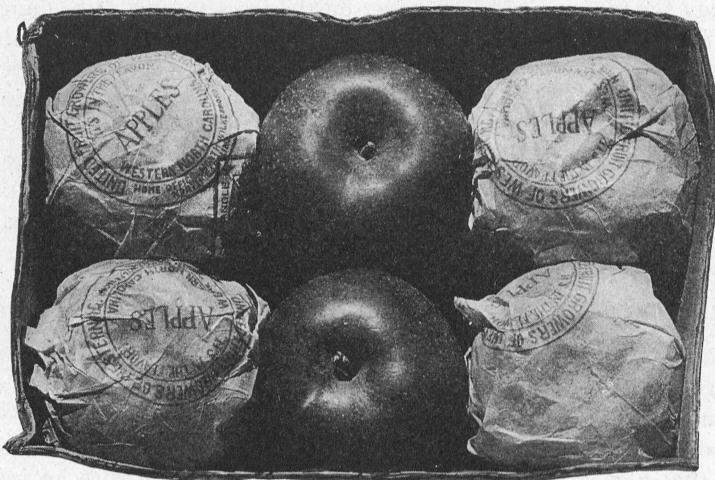


FIG. 21. Parcel-post package of apples sent from Triangle Orchard Company's storage house, February 25, 1914.

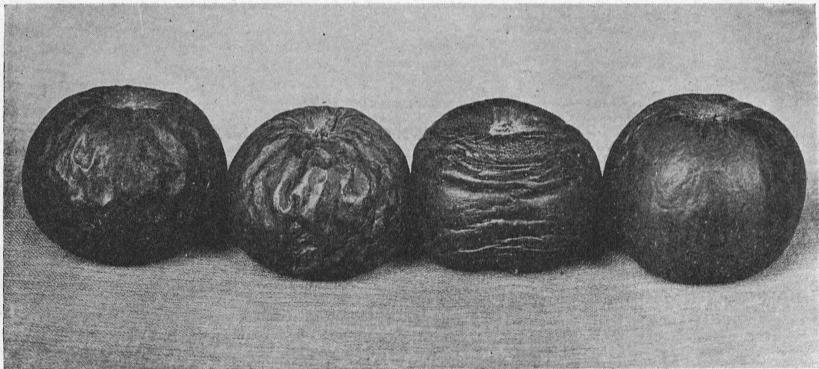


FIG. 22. Well-sprayed apples which dried up with age instead of rotting.

temperature at which fruit should be stored, but a general consensus of opinion as evidenced from time to time in the columns of *Ice and Refrigeration* shows that apples should be stored at a temperature of 30° to 40° and pears 33° to 36°. In an air-cooled storage it is, of course, not

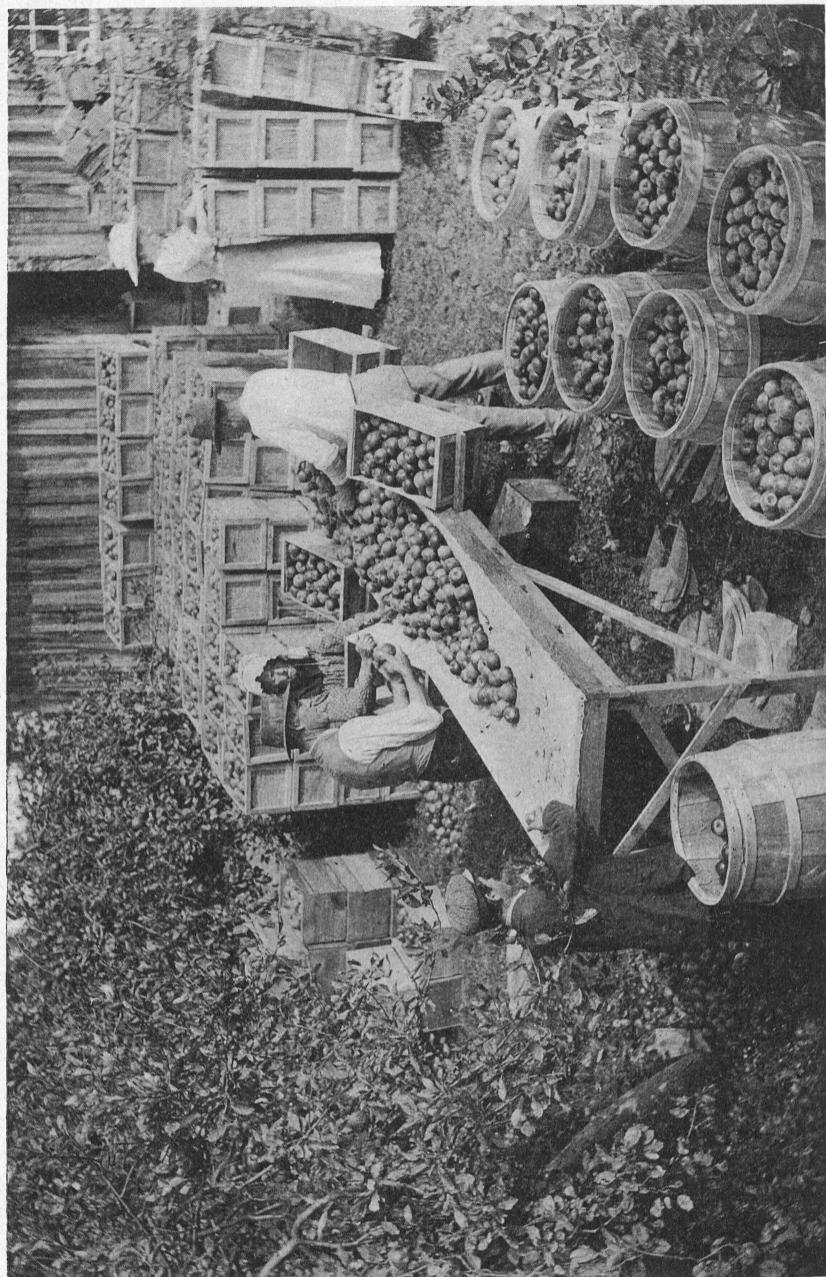


FIG. 23. Sorting apples for storage at Gold Medal Orchards, Oakwoods, N. C.

possible to maintain as low or as constant a temperature as under ice or mechanical refrigeration, but the fruit should be kept as cool as possible without freezing.

According to cold-storage authorities, the successful storage of fruit depends on four conditions:

1. Well-sprayed, carefully-handled fruit.
2. A low temperature.
3. An even temperature.
4. Sufficient moisture to prevent shrinkage and keep the fruit crisp and plump.

No fruit should ever be placed in storage that has not been thoroughly sprayed. In rare instances unsprayed fruit may look as sound as the sprayed product, but experience has shown that it never keeps as well. The spraying seems to disinfect the fruit so thoroughly that it has great resistance to external bacteria. On May 10th a Buckingham apple was sent me which at that late date showed not a sign of fungous injury. This well-known autumn variety is in prime eating condition about September 15th. This apple had been so thoroughly sprayed that there were no germs of decay about it, and when its season was past it simply dried up instead of rotting. Figure 22 shows four well-sprayed Red Limbertwig apples that stayed on my desk without decay until they became dried apples. Fruit showing bruises, fungous or insect injury, or other signs of decay, should never be placed in storage. Though it may temporarily delay its deterioration, a cool temperature will not prevent the ultimate decay of overripe or unsound fruit. Fruit should not be piled in the orchard and left to ripen, but should be placed in storage the morning after it is taken from the tree. The time elapsing between picking and storing very largely determines the life of the fruit.

Since air-cooled storage houses are ventilated incidentally in reducing the temperature, there is usually more than enough circulation to carry off all vitiated air and excess moisture from the ripening and drying out of the fruit. There is therefore practically no danger of damp, stagnant air causing moulds and rots on the fruit. There is, however, danger on the other hand of the fruit becoming too dry and shriveling. The fruit should be carefully watched during the storage period, and if found to be shriveling, water should be placed on the floor and allowed to evaporate to raise the humidity of the air about the fruit.

Of course, it should not be attempted to store fruit in bulk. It is impossible to properly ventilate a pile of fruit, and such handling could only result in loss in any kind of storage house. With fruit for immediate sale or for short storage it is best to box or barrel at once. Fruit keeps well in tight packages, especially if wrapped; but if held in storage for several months it will be necessary to repack before shipping in order to make up the shrinkage from drying out and have the packages full. For long storage in air-cooled houses most growers make a practice of

sorting the fruit into ventilated boxes at picking time and piling these up in the storage chamber layer on layer with scantlings between. Figure 23 shows fruit being boxed for storage in the Gold Medal Orchards at Oakwoods, Wilkes County, N. C. The fruit is not handled at all in storage, but is left wholly undisturbed until it is packed for shipping.

Wrapping of fruit for storage retards ripening and lengthens the keeping quality. There is also less loss of moisture. If a fruit happens to decay, the wrapper localizes the infection and prevents its spread to neighboring fruits. The wrapping of fruit is to be recommended for the storage of extra fancy fruit.

